We gather from the above report that on this occasion the principal phenomena observed were: (1) A distinct and perfect rainbow partially encircling the zenith, and so high above the moon as to be "almost in the zenith." (2) A beautiful cross of horizontal and vertical bars of a bright light yellow intersecting each other on the face of the moon. (3) Two similar fainter crosses at about 15° to the right and the left of the moon.

The general explanation of optical phenomena seen about the sun and moon was given on page 14 of this REVIEW for January, and page 56 of this REVIEW for February, 1895. (1) The arc of colored light or horizontal rainbow concentric with the zenith is caused by rays of sunlight that enter and leave the little vertical prisms of ice that are slowly settling down through the atmosphere. The top and bottom facets or faces of these crystals are inclined to each other and the refraction through these faces produces prismatic colors just as in an ordinary prism. The diameter of the rainbow circle around the zenith is smaller in proportion as the sun or moon is higher above the horizon. (2) The large cross of light yellow bars is due to the simple reflection of the moonlight from the outside facets of innumerable crystals of ice, all of which are slowly settling with their axes vertical. (3) The small and fainter crosses on either side of the moon are due to two reflections from the interior surfaces of crystals.

A complete study of the phenomena of parhelia can be made by preparing a number of hollow prisms made in the exact shape of the crystals of snow and ice that occur in nature. These prisms should be made of thin plates of glass cemented together at the edges, and should be filled with water, whose refractive and dispersive powers are of course very nearly the same as those of ice. Let such a prism be suspended in the sunlight in various positions with reference to the zenith, and in the position that it assumes when falling slowly through the air. Set it to revolving rapidly, as it may do when falling freely. If a special bright reflection is seen when viewed from a certain direction then this represents the position of a mock sun due to total reflection within the prism. If prismatic colors are seen this represents the position of a rainbow. If a moderately bright reflection from an external surface is seen this gives the location of some one of the numerous bands of light that may occur.

THE COLD SUMMER OF 1816.

An article in the New York Sun copied into the Iowa Monthly Review for July, 1895, gives some details about the remarkable summer of 1816, as remembered by James Winchester of Vermont. It is said that in June of that year snow fell to the depth of three inches in New York, Pennsylvania, and New Jersey on the 17th; five inches in all the New England States, except three inches in Vermont. There was snow and ice in every month of this year. The storm of June 17 was as severe as any that ever occurred in the depth of winter; it began about noon, increasing in fury until night, by which time the roads were impassable by reason of the snow drifts; many were bewildered in the blinding storm and frozen to death. During June, July, and August the wind was continuously from the north, fierce and cold; July was colder than June, and August colder than July; there was a heavy snowstorm August 30th. The first two weeks in September brought the first warm weather of the year, but on the 16th of that month the cold weather suddenly returned and continued increasing until winter. The year 1816 had neither spring, summer, nor autumn. The only crop of corn raised in that part of Vermont that summer was saved by keeping bonfires burning around the cornfield night and day. The crop of 1817 was raised from the seed of 1815. The summer of 1817 was one of the hottest and driest ever known in that region.

NOTE.—The preceding statement agrees with what we may gather from the interesting book by Charles Peirce, published in Philadelphia in 1847, entitled "A Meteorological Account of the Weather in Philadelphia," from January 1, 1790 to January 1, 1847. A record was begun by Peirce, at Portsmouth, N. H., in 1793, and was continued in Philadelphia, where he had access to numerous other journals. According to this work the mean temperatures at Philadelphia during the year 1816 were the lowest on record, and were as follows: January, 32°; February, 28°; March, 36°; April, 47°; May, 57°; June, 64°; July, 68°; August, 66°; September, 62°; October, 52°; November, 42°; December, 32°.

On page 247 Mr. Peirce says:

The temperature of the whole year was only 49°, it being the coldest year we have on our record. Although there was no uncommonly cold weather during the three winter months, yet there was ice during every month in the year, not excepting June, July, and August. There was scarcely a vegetable came to perfection north and east of the Potomac. The cold weather during the summer not only extended through America, but throughout Europe. One of the most celebrated meteorologists in England, on reviewing the weather of the year, said: "It would ever be remembered that 1816 was a year in which there was no summer, and the temperature of the year (as a whole) was the lowest ever known." It was also the coldest summer ever known in the West Indies and in Africa. The medium temperature of the whole year in Philadelphia was only 49°.

A POPULAR SUBSTITUTE FOR THE BAROMETER.

In The Weather and Crops, published by the Illinois State Weather Service, we find a short description of a simple instrument that serves the purpose of showing approximately the changes that may be going on in the pressure of the air. The description reads as follows:

If a large-mouthed glass jar—fruit or pickle jar will do—be filled about two-thirds full of water, and in it be placed, inverted, a smaller long-necked flask, with mouth entering the water, the increasing or decreasing pressure of the outer atmosphere will cause the water to rise or fall within the flask. Clear, fine weather will be foretold by the water rising in the flask; stormy, wet, or bad weather by the water falling.

The device thus explained will, undoubtedly, show variations in atmospheric pressure, and all the more correctly in proportion as the temperature of the air within the flask remains stationary. If we wish to be at all accurate, or if we wish not to be misled by the effects of changes of temperature we must either keep the temperature constant or else make a numerical allowance for the effect of its variations. If the temperature within the flask rises 1 degree Fahrenheit, its confined air will expand by $\frac{1}{492}$ of its volume, and the water in the neck of the flask will be pushed down to a corresponding amount. On the other hand, if the atmospheric pressure should diminish by 0.06 of an inch below a normal pressure of 30 inches, the air within the flask being slightly relieved of its pressure would expand by the $\frac{1}{492}$ part of its volume, and the water in the neck pushed down as before. In so far as we cannot rely upon the constant temperature of the air within the flask we must therefore make an allowance of 0.06 for each degree of change. As this apparatus is so sensitive to temperature it may therefore be considered as a thermometer when the atmospheric pressure is constant. In fact this is known as the first form of air thermometer which was used by the physician Sanctorius, who learned it from Galileo in 1596, and it was the study of the fluctuations of this apparatus that contributed greatly toward the discovery of the pressure of the air and the invention of mercurial barometers and the ordinary spirit thermometer. If one wishes to use this apparatus as a barometer, and needs, therefore, to know its temperature correctly to within a degree, he will find it best to fasten the smaller flask and its long neck, or, still better, a long glass tube, permanently within the outer glass jar and fill the latter with water so that the whole flask is covered. A thermometer whose bulb is under the water will give the temperature of the water and the air within it, and, if the water be well stirred, all will have the same temperature.

An early modification of this simple barometer was for a long time manufactured by expert glass blowers in Florence, and was called the Florentine experiment. In this arrangement the inverted flask was made quite small, and weighted so that it floated freely like a small balloon in a jar of water; when the temperature of the water rose, or when the atmospheric pressure diminished, the air within the flask expanded and the density of the balloon diminished, so that it rose to the surface. If, however, the glass flasks are hermetically sealed so that the air within them can not expand and change their density to any extent; then, if the water in the jar becomes warmer, the flasks will descend because their own density will then be greater than that of the water. If, again, the open mouth of the jar be hermetically sealed, inclosing air above the water, we have a new condition, viz. the external atmospheric pressure has no longer any influence, while the changes of temperature have a twofold influence; by expanding the water its density is diminished, but by expanding the air above the water the quasi atmospheric pressure within the jar is increased. These four combinations, namely, closed or open flasks floating in closed or open jars of water, formed what are known as the Florentine and the Stuttgart experiments with the Cartesian divers, and the phenomena that they exhibited were widely discussed by Europeans in the seventeenth century.

THE CARBONIC ACID GAS IN THE ATMOSPHERE.

Both geology and agriculture are interested equally with meteorology in the part played by the small quantity of carbonic acid gas that exists in the atmosphere. The leaves absorb and assimilate a portion; the falling raindrops and the surface water of the ocean absorb another portion; it is exhaled from the lungs and given off in still greater quantities from every burning substance. It may accumulate temporarily in some regions, but the slow diffusion and swifter winds carry it away. It ought to diminish as we ascend above the earth's surface, but the rapidly rising and falling currents of air tend to preserve a fairly uniform mixture very much as they do in the case of aqueous vapor. Evidently there is a general balance between the production and absorption of carbonic acid gas, so that, like the temperature of the air and the quantity of rain or any other meteorological element, we find no great progressive secular increase or diminution. The following paragraphs, reviewing the latest addition to our knowledge of this subject, are translated from Wollny's Forschungen (1895, Vol. XVIII, p. 409):

"In order to arrive at a more accurate knowledge of the distribution of carbonic acid gas in the atmosphere, S. A. Andrée, the Swedish aeronaut, collected samples of air in exhausted tubes on most of his balloon voyages, and took care, moreover, to do this while the balloon was descending and as far as possible from the car of the balloon in order to avoid contamination from any gases that might come from the balloon itself. These samples were analyzed at the high school in Stockholm by Miss Palmqvist, who had already published an extensive investigation into the carbonic acid gas contained in the atmosphere over the experimental field at Stockholm.

"As compared with the data for the earth's surface near Stockholm, published by Palmqvist, and those for Wexholm, published by Selanders, the Andrée results, as shown in a table arranged according to the altitudes of the respective layers of air do not prove any diminution of carbonic acid gas with altitude up to the highest point, 4,300 meters, attained in these balloon ascensions. On the other hand the percentages of carbonic acid gas by volume throughout the different strata of air are very much the same as those observed at the surface of the earth. On the average we find in 10,000 volumes at the earth's surface from 3.03 to 3.20 volumes of carbonic acid gas; at altitudes of 1,000 to 3,000 meters, 3.23 volumes; at altitudes of 3,000 to 4,000 meters, 3.24 volumes. On the other hand notable differences are remarked when we arrange the percentages for the higher and freer strata of air according to the direction of the wind, although the differences that are thus brought out are not entirely systematic, as might have been expected, because in the atmosphere many currents intersect so that more or less appreciable mixtures of masses of air having various percentages of carbonic acid gas must occur. But this apparent dependence on the wind must suggest further investigation as to how far the carbonic acid gas present in the atmosphere depends upon the place from which the air came, and especially on the contact of this air with the earth's surface, since it is to be assumed that the absorption and development of carbonic acid gas takes place at the earth's surface and not in the atmosphere.

"From this point of view the author has, by utilizing the weather reports of the Central Meteorological Institution at Stockholm, classified the measurements of carbonic acid gas at the two stations above mentioned, according as they were made within areas of barometric maxima or minima, and has compared these values with the corresponding monthly means. At both stations the percentages of carbonic acid gas are found to be above the monthly means in the maxima, but below in the minima. If we may generalize this result, it might be said that a descending mass of air brings with it a higher percentage of carbonic acid gas, which is subsequently diminished by absorption near the earth's surface, so that the ascending current has a smaller percentage.

"The hypothesis that the larger percentage in the maxima is caused by the calmness of the atmosphere seems to be disproved by the fact that scarcely half of the cases cited in Andrée's table showed a perfect calm and that these occurred in the months of December and January, when a large quantity of carbonic acid gas is thrown into the quiet atmosphere by the combustion of wood and coal in the ordinary industrial operations. We must indeed assume that air which is rich in carbonic acid gas descends to the earth's surface from the upper strata of the atmosphere; but we must not conclude that, in general, the atmosphere should therefore be found to be richer in carbonic acid gas during high barometric pressure and poorer during low pressure. On the contrary, other matters ordinarily make themselves felt in such a way that the influence of high pressure and descending currents is entirely obliterated and pushed into the background. The observations at Wexholm demonstrate that the north and northwest land winds contain much more carbonic acid gas than the southeast ocean winds, whose air, flowing over the surface of the Baltic, has suffered a great loss of carbonic acid gas.

"In order to test the question whether the air within an area of barometric high pressure is really richer in carbonic acid gas than in a barometric minimum one must take account of the above-mentioned and other disturbing influences. For the present Andrée thinks himself justified in adopting the conclusion that in the region investigated by him the lower atmospheric strata received more carbonic acid gas from the upper strata than from the earth's surface. This agrees with the observation made by Nansen on his Greenland expedition at altitudes of 2,300 to 2,700 meters and at temperatures of —19.4° to —24° C. in a locality where the occurrence of carbonic acid gas arising from artificial combustion was out of the question; here it was found that the percentage of carbonic acid gas was as large and even larger than in the experimental field near Stockholm. Andrée does not consider that it is yet time to offer any explanation of this larger percentage